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(Formerly NUREG-75/087)

U.S. NUCLEAR REGULATORY COMMISSION

# STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

## SECTION 3.8.4 OTHER SEISMIC CATEGORY I STRUCTURES

REVIEW RESPONSIBILITIES

Primary - Structural Engineering Branch (SEB)

Secondary - None

## I. AREAS OF REVIEW

The following areas relating to all seismic Category I structures and other safety-related structures that may not be classified as seismic Category I, other than the containment and its interior structures, are reviewed:

1. Description of the Structures

The descriptive information including plans and sections of each structure, is reviewed to establish that sufficient information is provided to define the primary structural aspects and elements relied upon for the structure to perform the safety-related function. Also reviewed is the relationship between adjacent structures including the separation provided or structural ties, if any. Among the major plant structures that are reviewed, together with the descriptive information reviewed for each, are the following:

a. Containment Enclosure Building

The containment enclosure building, which may surround all or part of the primary concrete or steel containment structure, is primarily intended to reduce leakage during and after a loss-of-coolant (LOCA) from within the containment. Concrete enclosure buildings also protect the primary containment, which may be of steel or concrete, from outside hazards.

The enclosure building is usually either a concrete structure or a structural steel and metal siding building.

Where it is a concrete structure, it usually has the geometry of the containment and, as applicable, the descriptive information reviewed is similar to that of a concrete containment as contained in subsection I.1 of Standard Review Plan Section 3.8.1.

Where it is a structural steel and metal siding building, the following items are reviewed: general arrangement of the building including its foundations, wall, and roof; any bracing and lateral ties provided for the stability of the building; the roof supports which may bear on the dome of the containment; and major corner and siding joint connections.

b. Auxiliary Building

The auxiliary building, which is usually adjacent to the containment and which may be shared by the two containments in two-unit plants, is usually of reinforced concrete and structural steel construction. The general arrangement of the structural walls, columns, floors, roof, and any removable sections, is reviewed.

c. Fuel Storage Building

The fuel storage building, which may be independent or part of the auxiliary building, is also of reinforced concrete and structural steel. It houses the new fuel storage area and the spent fuel pool. In addition to the information reviewed for the auxiliary building, the general arrangement of the spent fuel pool is reviewed including its foundations and walls.

d. Control Building

The control room is located in most plants within the auxiliary building. However, where it is located in a separate building, usually called the control building, the building is reviewed as a separate structure. To provide missile protection and shielding, this building is usually of reinforced concrete and the descriptive information reviewed is similar to that reviewed for the auxiliary building.

e. Diesel Generator Building

The emergency diesel generators are, in some plants, located within the auxiliary building. However, they may also be located in a separate building called the diesel generator building. Again, this is usually a reinforced concrete structure and the descriptive information reviewed is similar to that reviewed for the auxiliary building.

f. Other Structures

In most plants, there are several miscellaneous seismic Category I structures and other structures that may be safety-related but, because of other design provision, may not be classified as seismic Category I. These structures are usually either of reinforced concrete or structural steel, or a combination thereof. The descriptive information reviewed for such structures is similar to that reviewed for the auxiliary building. Among such structures are: pipe and electrical conduit tunnels, waste storage facilities, stacks, intake structures, pumping stations, and cooling towers.

Further, the reviewer may encounter special safety-related structures such as emergency cooling water tunnels, embankments, concrete dams, and water wells. Such structures are reviewed on a case-by-case basis. The descriptive information provided is reviewed to understand the structural behavior of these structures, specifically during seismic events and plant process conditions during which such structures are required to remain functional.

g. Masonry Walls

These are walls, partitions or radiation shields which are components of the structures listed above. They are constructed of concrete masonry units (CMU) bonded with mortar in single or multiple wythes and may be reinforced horizontally as well as vertically. The arrangement and configuration of these walls is reviewed.

2. <u>Applicable Codes, Standards, and Specifications</u>

The information pertaining to design codes, standards, specifications, regulatory guides, and other industry standards that are applied in the design, fabrication, construction, testing, and surveillance of seismic Category I structures, is reviewed.

3. <u>Loads and Loading Combinations</u>

Information pertaining to the applicable design loads and various load combinations thereof is reviewed. The loads normally applicable to seismic Category I structures include the following:

a. Those loads encountered during normal plant startup, operation, and shutdown, including dead loads, live loads, thermal loads due to operating temperature, and hydrostatic loads such as in those spent in fuel pools.

b. Those loads to be sustained during severe environmental conditions, including those induced by the operating basis earthquake (OBE) and the design wind specified for the plant.

c. Those loads to be sustained during extreme environmental conditions, including those induced by the safe shutdown earthquake (SSE) and the design tornado specified for the plant.

d. Those loads to be sustained during abnormal plant conditions. Such abnormal plant conditions include the postulated rupture of high-energy piping. Loads induced by such an accident may include elevated temperatures and pressures within or across compartments, and possibly jet impingement and impact forces associated with such ruptures.

The various combinations of the above loads that are normally postulated and reviewed include normal operating loads; normal operating loads with severe environmental loads; normal operating loads with extreme environmental loads; normal operating loads with abnormal loads; normal operating loads with severe environmental and abnormal loads; and normal operating with extreme environmental and abnormal loads.

The loads and load combinations described above are generally applicable to all types of structures. However, other site-related loads might also be applicable. Such loads, which are not normally combined with abnormal loads, include those induced by floods, potential aircraft crashes, explosive hazards in proximity to the site, and projectiles and missiles generated from activities of nearby military installations.

4. Design and Analysis Procedures

The design and analysis procedures used for Category I structures are reviewed with emphasis on the extent of compliance with the ACI 349 Code (Ref. 1)* for concrete structures and with the AISC Specifications (Ref. 3) for steel structures, including the following areas:

a. General assumptions on boundary conditions.

b. The expected behavior under loads and the methods by which vertical and lateral loads and forces are transmitted from the various elements to their supports and eventually to the foundation of the structure.

c. The computer programs that are utilized.

d. A design report on Category I structures is reviewed (Appendix C).

e. A structural audit is performed (Appendix B).

f. The design of the spent fuel pool and racks is reviewed (Appendix D).

5. Structural Acceptance Criteria

The design limits imposed on the various parameters that serve to quantify the structural behavior of each structure and its components are reviewed, specifically with respect to stresses, strains, gross deformations, and factors of safety against structural failure. For each load combination specified, the specified allowable limits are compared with the acceptable limits delineated in Section II.5 of this plan.

6. Materials, Quality Control, Special Construction Techniques, and Quality Assurance

Information on the materials that are used in the construction of Category I structures is reviewed. Among the major materials of construction that are reviewed are the concrete ingredients, the reinforcing bars and splices, and the structural steel and anchors.

The quality control parameters that are proposed for the fabrication and construction of Category I structures are reviewed including nondestructive examination of the materials to determine physical properties, placement of concrete, and erection tolerances.

*Whenever reference is made to ACI 349, it implies that the code is augmented by Regulatory Guide 1.142 (Ref. 2).

Special construction techniques, if proposed, are reviewed on a case-by-case basis to determine their effects on the structural integrity of the completed structure.

In addition, the information contained in items a, b, and c of subsection I.6 of Standard Review Plan Section 3.8.3 is also reviewed.

7. Testing and Inservice Surveillance Programs

If applicable, any post-construction testing and inservice surveillance programs are reviewed on a case-by-case basis.

8. Masonry Walls

Areas of review pertaining to masonry walls should include, as a minimum, those items identified in Appendix A to this SRP section.

SEB coordinates other branches evaluations that interface with structural engineering aspects of the review as follows: determination of structures which are subject to quality assurance programs in accordance with the requirements of Appendix B to 10 CFR Part 50 is performed by the Mechanical Engineering Branch (MEB) as part of its primary review responsibility for SRP Sections 3.2.1 and 3.2.2. SEB will perform its review of safety-related structures on that basis. Determination of pressure loads from high energy lines located in safety related structures other than containment is performed by the Auxiliary Systems Branch (ASB) as described as part of its primary review responsibility for SRP Section 3.6.1. SEB accepts the loads thus generated as approved by the ASB to be included in the load combination equations of this SRP section. Determination of loads generated due to pressure under accident conditions is performed by the Containment Systems Branch (CSB) as part of its primary review responsibility for SRP Section 6.2.1. SEB accepts the loads thus generated, as approved by the CSB to be included in the load combinations in this SRP section. The review for quality assurance is coordinated and performed by the Quality Assurance Branch as part of its primary review responsibility for SRP Section 17.0.

For those areas of review identified above as being reviewed as part of the primary review responsibility of other branches, the acceptance criteria necessary for the review and their methods of application are contained in the referenced SRP section of the corresponding primary branch.

## II. ACCEPTANCE CRITERIA

SEB acceptance criteria for the design of structures other than containment are based on meeting the relevant requirements of the following regulations:

A. 10 CFR Part 50, §50.55a and General Design Criterion 1 as they relate to safety related structures being designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety function to be performed.

B. General Design Criterion 2 as it relates to the design of the safety-related structures being capable to withstand the most severe natural phenomena such as wind, tornadoes, floods, and earthquakes and the appropriate combination of all loads.

C. General Design Criterion 4 as it relates to safety-related structure being capable of withstanding the dynamic effects of equipment failures including missiles and blowdown loads associated with the loss of coolant accidents.

D. General Design Criterion 5 as it relates to sharing of structures important to safety unless it can be shown that such sharing will not significantly impair their validity to perform their safety functions.

E. Appendix B to 10 CFR Part 50 as it relates to the quality assurance criteria for nuclear power plants.

The Regulatory Guides and industry standards identified in item 2 of this subsection provides information, recommendations and guidance and in general describes a basis acceptable to the staff that may be used to implement the requirements of 10 CFR Part 50, §50.55a and GDC 1, 2, 4, 5 and Appendix B to 10 CFR Part 50. Also, specific acceptance criteria necessary to meet the relevant requirements of these regulations for the areas of review, described in subsection I of this SRP section are as follows:

1. Description of the Structures

The descriptive information in the SAR is considered acceptable if it meets the minimum requirements set forth in Section 3.8.4.1 of the "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants" (Ref. 4).

Deficient areas of descriptive information are identified by the reviewer and a request for additional information is initiated at the application acceptance review. New or unique design features that are not specifically covered in the "Standard Format..." may require a more detailed review. The reviewer determines the additional information that may be required to accomplish a meaningful review of the structural aspects of such new or unique features.

2. Applicable Codes, Standards, and Specifications

The design, materials, fabrication, erection, inspection, testing, and surveillance, if any, of Category I structures are covered by codes, standards, and guides that are either applicable in their entirety or in portions thereof. A list of such documents is as follows:

| Specification | Title |
|---|---|
| ACI 349 | "Code Requirements for Nuclear Safety-Related Concrete Structures" |
| AISC | "Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings" |
| **Regulatory Guides** | |
| 1.10 | Mechanical (Caldweld) Splices in Reinforcing Bars of Category I Concrete Structures |

| | |
|---|---|
| 1.15 | Testing of Reinforcing Bars for Category I Concrete Structures |
| 1.55 | Concrete Placement in Category I Structures |
| 1.69 | Concrete Radiatjon Shields for Nuclear Power Plants |
| 1.91 | Evaluations of Explosions Postulated to Occur on Transportation Routes Near Nuclear Power Plants |
| 1.94 | Quality Assurance Requirements for Installation, Inspection, and Testing of Structural Concrete |
| 1.115 | Protection Against Low Trajectory Turbine Missiles |
| 1.142 | Safety-Related Concete Structures for Nuclear Power Plants (Other Than Reactor Vessels and Containments) |
| 1.143 | Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in LWR Plants |

3. Loads and Load Combinations

The specified loads and load combinations are acceptable if found to be in accordance with the following:

a. Loads, Definitions, and Nomenclature

All the major loads to be encountered or to be postulated are listed below. All the loads listed, however, are not necessarily applicable to all the structues and their elements. Loads and the applicable load combinations for which each structure has to be designed will depend on the conditions to which that particular structure may be subjected.

Normal loads, which are those loads to be encountered during normal plant operation and shutdown, include:

D - Dead loads or their related internal moments and forces, inluding any permanent equipment loads.

L - Live loads or their related internal moments and forces, including any movable equipment loads and other loads which vary with intensity and occurrence, such as soil pressure.

$T_o$ - Thermal effects and loads during normal operating or shutdown conditions, based on the most critical transient or steady state condition.

$R_o$ - Pipe reactions during normal operating or shutdown conditions, based on the most critical transient or steady state condition.

Severe environmental loads include:

E - Loads generated by the operating basis earthquake.

W - Loads generated by the design wind specified for the plant.

Extreme environmental loads include:

E' - Loads generated by the safe shutdown earthquake.

$W_t$ - Loads generated by the design tornado specified for the plant. Tornado loads include loads due to the tornado wind pressure, the tornado-created differential pressure, and to tornado-generated missiles.

Abnormal loads, which are those loads generated by a postulated high-energy pipe break accident, include:

$P_a$ - Pressure equivalent static load within or across a compartment generated by the postulated break, and including an appropriate dynamic load factor to account for the dynamic nature of the load.

$T_a$ - Thermal loads under thermal conditions generated by the postulated break and including $T_o$.

$R_a$ - Pipe reactions under thermal conditions generated by the postulated break and including $R_o$.

$Y_r$ - Equivalent static load on the structure generated by the reaction on the broken high-energy pipe during the postulated break, and including an appropriate dynamic load factor to account for the dynamic nature of the load.

$Y_j$ - Jet impingement equivalent static load on a structure generated by the postulated break, and including an appropriate dynamic load factor to account for the dynamic nature of the load.

$Y_m$ - Missile impact equivalent static load on a structure generated by or during the postulated break, as from pipe whipping, and including an appropriate dynamic load factor to account for the dynamic nature of the load.

In determining an appropriate equivalent static load for $Y_r$, $Y_j$, and $Y_m$, elasto-plastic behavior may be assumed with appropriate ductility ratios, provided excessive deflections will not result in loss of function of any safety-related system.

b. Load Combinations for Concrete Structures

For concrete structures, the load combinations are acceptable if found in accordance with the following:

(i) For service load conditions, either the working stress design (WSD) method as outlined in ACI 318 Code or the strength design method may be used.

(a) If the WSD method is used, the following load combinations should be considered:

(1) $D + L$

(2) $D + L + E$

(3) $D + L + W$

If thermal stresses due to $T_o$ and $R_o$ are present, the following combinations should be also considered:

(4) $D + L + T_o + R_o$

(5) $D + L + T_o + R_o + E$

(6) $D + L + T_o + R_o + W$

Both cases of L having its full value or being completely absent should be checked.

(b) If the strength design method is used, the following load combinations should be considered:

(1) $1.4\ D + 1.7\ L$

(2) $1.4\ D + 1.7\ L + 1.9\ E$

(3) $1.4\ D + 1.7\ L + 1.7\ W$

If thermal stresses due to $T_o$ and $R_o$ are present, the following combinations should also be considered:

(4) $(0.75)\ (1.4D + 1.7L + 1.7T_o + 1.7R_o)$

(5) $(0.75)\ (1.4D + 1.7L + 1.9E + 1.7T_o + 1.7R_o)$

(6) $(0.75)\ (1.4D + 1.7L + 1.7W + 1.7T_o + 1.7R_o)$

In addition, the following combinations should be considered:

(7) $1.2\ D + 1.9\ E$

(8) $1.2\ D + 1.7\ W$

(ii) For factored load conditions which represent extreme environmental, abnormal, abnormal/severe environmental, and abnormal/extreme environmental conditions, the strength design method should be used and the following load combinations should be considered:

(a) $D + L + T_o + R_o + E'$

(b) $D + L + T_o + R_o + W_t$

(c) $D + L + T_a + R_a + 1.5\ P_a$

(d) $D + L + T_a + R_a + 1.25\ P_a + 1.0\ (Y_r + Y_j + Y_m) + 1.25\ E'$

(e) $D + L + T_a + R_a + 1.0\ P_a + 1.0\ (Y_r + Y_j + Y_m) + 1.0\ E'$

In combinations (c), (d), and (e), the maximum values of $P_a$, $T_a$, $R_a$, $Y_j$, $Y_r$, and $Y_m$, including an appropriate dynamic load factor, should be used unless a time-history analysis is performed to justify otherwise. Combinations (b) and (d) and (e) and the corresponding structural acceptance criteria of subsection II.5 of this SRP section should be satisfied first without the tornado missile load in (b) and without $Y_r$, $Y_j$, and $Y_m$ in (d) and (e). When considering these concentrated loads, local section strength capacities may be exceeded provided there will be no loss of function of any safety-related system.

Where any load reduces the effects of other loads, the corresponding coefficient for that load should be taken as 0.9 if it can be demonstrated that the load is always present or occurs simultaneously with other loads. Otherwise the coefficient for that load should be taken as zero.

Where the structural effects of differential settlement, creep, or shrinkage may be significant, they should be included with the dead load, D, as applicable.

c. Load Combinations for Steel Structures

For steel interior structures, the load combinations are acceptable if found in accordance with the following:

(i) For service load conditions, either the elastic working stress design methods of Part 1 of the AISC specifications, or the plastic design methods of Part 2 of the AISC specifications, may be used.

(a) If the elastic working stress design methods are used, the following load combinations should be considered:

(1) $D + L$

(2) $D + L + E$

(3) $D + L + W$

If thermal stresses due to $T_o$ and $R_o$ are present, the following combinations should be also considered:

(4) $D + L + T_o + R_o$

(5) $D + L + T_o + R_o + E$

(6) $D + L + T_o + R_o + W$

(b) If plastic design methods are used, the following load combinations should be considered:

(1) $1.7\ D + 1.7\ L$

(2) $1.7\ D + 1.7\ L + 1.7\ E$

(3) $1.7\ D + 1.7\ L + 1.7\ W$

If thermal stresses due to $T_o$ and $R_o$ are present, the following combinations should also be considered:

(4) $1.3\ (D + L + T_o + R_o)$

(5) $1.3\ (D + L + E + T_o + R_o)$

(6) $1.3\ (D + L + W + T_o + R_o)$

(ii) For factored load conditions the following load combinations should be considered:

(a) If elastic working stress design methods are used:

(1) $D + L + T_o + R_o + E'$

(2) $D + L + T_o + R_o + W_t$

(3) $D + L + T_a + R_a + P_a$

(4) $D + L + T_a + R_a + P_a + 1.0\ (Y_r + Y_j + Y_m) + E$

(5) $D + L + T_a + R_a + P_a + 1.0\ (Y_r + Y_j + Y_m) + E'$

(b) If plastic design methods are used:

(1) $D + L + T_o + R_o + E'$

(2) $D + L + T_o + R_o + W_t$

(3) $D + L + T_a + R_a + 1.5\ P_a$

(4) $D + L + T_a + R_a + 1.25\ P_a + 1.0\ (Y_r + Y_j + Y_m) + 1.25\ E$

(5) $D + L + T_a + R_a + 1.0\ P_a + 1.0\ (Y_r + Y_j + Y_m) + E'$

In the above factored load combinations, thermal loads can be neglected when it can be shown that they are secondary and self-limiting in nature and where the material is ductile.

In combinations (3), (4), and (5), the maximum values of $P_a$, $T_a$, $R_a$, $Y_j$, $Y_r$, and $Y_m$, including an appropriate dynamic load factor, should be used unless a time-history analysis is performed to justify otherwise. Combinations (2), (4) and (5) and the corresponding structural acceptance criteria of subsection II.5 of this SRP section should first be satisfied without the tornado missile load in (2) and without $Y_r$, $Y_j$, and $Y_m$ in (4) and (5). When considering these concentrated loads, local section strength may be exceeded provided there will be no loss of function of any safety-related system.

Where any load reduces the effects of other loads, the corresponding coefficient for that load should be taken as 0.9, if it can be demonstrated that the load is always present or occurs simultaneously with other loads. Otherwise, the coefficient for that load should be taken as zero.

Where the structural effect of differential settlement may be significant it should be included with the dead load, D.

4. Design and Analysis Procedures

The design and analysis procedures utilized for Category I structures, including assumptions on boundary conditions and expected behavior under loads, are acceptable if found in accordance with the following:

a. For concrete structures, the procedures are in accordance with ACI-349, "Code Requirements for Nuclear Safety Related Structures" (Ref. 1).

b. For steel structures, the procedures are in accordance with the AISC "Specification..." (Ref. 3).

c. Computer programs are acceptable if the validation provided is found in accordance with procedures delineated in subsection II.4.e of SRP Section 3.8.1.

d. Design report is considered acceptable if it contains the information specified in Appendix C to this SRP section.

e. Structural audit is conducted in accordance with the provisions of Appendix B to this SRP section.

f. Design of spent fuel pool and rods is considered acceptable when the requirements of Appendix D to this SRP section are met.

5. Structural Acceptance Criteria

For each of the loading combinations delineated in subsection II.3 of this SRP section, the following defines the allowable limits which constitute the structural acceptance criteria:

a. <u>In Combinations for Concrete</u>

| | Limit |
|---|---|
| Paragraphs 3.b.(i)(a)(1), (2), and (3) . . . . . . . . | S[(1)] |
| Paragraphs 3.b.(i)(a)(4), (5), and (6) . . . . . . . . | 1.3 S |
| Paragraphs 3.b.(i)(b)(1), (2), and (3) . . . . . . . . | U[(2)] |
| Paragraphs 3.b.(i)(b)(4), (5), and (6) . . . . . . . . | U |
| Paragraphs 3.b.(i)(6), (7), and (8). . . . . . . . . . | U |
| Paragraphs 3.b.(ii)(a), (b), (c), (d), and (e) . . . | U |

b. <u>In Combinations for Steel</u>

| | Limit |
|---|---|
| Paragraphs 3.c.(i)(a)(1), (2), and (3) . . . . . . . . | S |
| Paragraphs 3.c.(i)(a)(4), (5), and (6) . . . . . . . . | 1.5 S |
| Paragraphs 3.c.(i)(b)(1), (2), and (3) . . . . . . . . | Y[(3)] |
| Paragraphs 3.c.(i)(b)(4), (5), and (6) . . . . . . . . | Y |
| Paragraphs 3.c.(ii)(a)(1), (2), (3), and (4)[(4)]. . . | 1.6 S |
| Paragraphs 2.(c)(ii)(a)(4), and (5)[(4)] . . . . . . . . | 1.7 S |
| Paragraphs 3.c.(ii)(b)(1), (2), (3), (4), and (5). . | Y |

<u>Notes</u>

(1) S - For concrete structures, S is the required section strength based on the working stress design method and the allowable stresses defined in ACI 318 Code.

For structural steel, S is the required section strength based on elastic design methods and the allowable stresses defined in Part 1 of the AISC "Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings" (Ref. 3)

The one-third increase in allowable stresses for concrete and steel due to seismic or wind loadings is not permitted.

(2) U - For concrete structures, U is the section strength required to resist design loads based on the strength design methods described in ACI 349 Code (Ref. 1).

(3) Y - For structural steel, Y is the section strength required to resist design loads and based on plastic design methods described in Part 2 of the AISC "Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings" (Ref. 3).

(4) - For these two combinations, in computing the required section strength, S, the plastic section modulus of steel shapes, except for those which do not meet the AISC criteria for compact sections, may be used.

6. Materials, Quality Control, and Special Construction Techniques

For Category I structures outside the containment, the acceptance criteria for materials, quality control, and any special construction techniques are in accordance with the codes and standards indicated in subsection I.6 of SRP Section 3.8.3, as applicable.

7. Testing and Inservice Surveillance Requirements

At present there are no special testing or inservice surveillance requirements for Category I structures outside the containment. However, where some requirements become necessary for special structures, such requirements are reviewed on a case-by-case basis.

8. Masonry Walls

Acceptance criteria for masonry walls are contained in Appendix A to this SRP section.

## III. REVIEW PROCEDURES

The reviewer selects and emphasizes material from the review procedures described below, as may be appropriate for a particular case.

1. Description of the Structures

After the type of structure and its functional characteristics are identified, information on similar and previously licensed plants is obtained for reference. Such information, which is available in safety analysis reports and amendments of previous license applications, enables identification of differences for the case under review. These differences require additional scrutiny and evaluation. New and unique features that have not been used in the past are of particular interest and are thus examined in greater detail. The information furnished in the SAR is reviewed for completeness in accordance with the "Standard Format..." (Ref. 4). A decision is then made with regard to the sufficiency of the descriptive information provided. Any additional required information not provided is requested from the applicant at an early stage of the review process.

2. Applicable Codes, Standards, and Specifications

The list of codes, standards, guides, and specifications is compared with the list in subsection II.2 of this SRP section. The reviewer assures himself that the appropriate code or guide is utilized and that the applicable edition and stated effective addenda are acceptable.

3. Loads and Loading Combinations

The reviewer verifies that the loads and load combinations are as conservative as those specified in subsection II.3 of this SRP section. Any deviations from the acceptance criteria for loads and load combinations that have not been adequately justified are identified as unacceptable and transmitted to the applicant.

4. Design and Analysis Procedures

The reviewer assures himself that for the design and analysis procedures, the applicant is utilizing the ACI-349 Code (Ref. 1) and the ASIC Specifications for concrete and steel structures (Ref. 3), respectively.

Any computer programs that are utilized in the design and analysis of the structure are reviewed to verify their validity in accordance with the acceptance criteria delineated in subsection II.4.e of SRP Section 3.8.1.

The reviewer assures that the provisions specified in subsection II.4 of this SRP section regarding design report, structural audits and design of spent fuel pool and racks are met.

5. Structural Acceptance Criteria

The limits on allowable stresses and strains in the concrete, reinforcement, structural steel, etc., are compared with the corresponding allowable stresses specified in Section II.5 of this SRP section. If the applicant proposes to exceed some of these limits for some of the load combinations and at some localized points on the structure, the justification provided to show that the structural integrity of the structure will not be affected is evaluated. If such justification is determined to be inadequate, the proposed deviations are identified and transmitted to the applicant with a request for the required additional justification and bases.

6. Materials, Quality Control, and Special Construction Techniques

The materials, quality control procedures, and any special construction techniques are compared with those referenced in subsection II.6 of this SRP section. If a new material not used in prior licensed cases is utilized, the applicant is requested to provide sufficient test and user data to establish the acceptability of such a material. Similarly, any new quality control procedures or construction techniques are reviewed and evaluated to assure that there will be no degradation of structural quality that might affect the structural integrity of the structure.

7. Testing and Inservice Surveillance Requirements

Any testing and inservice surveillance programs are reviewed on a case-by-case basis.

8. Masonry Walls

The reviewer should assure that the requirements identified in Appendix A to this SRP section are met.

## IV. EVALUATION FINDINGS

The reviewer verifies that sufficient information has been provided to satisfy the requirements of this SRP section, and concludes that his evaluation is sufficiently complete and adequate to support the following type of conclusive statement to be included in the staff's safety evaluation report:

The staff concludes that the design of safety-related structures other than containment or containment interior structures are acceptable and meets the relevant requirements of 10 CFR Part 50, §50.55a, and General Design Criteria 1, 2, 4, and 5. This conclusion is based on the following:

1. The applicant has met the requirements of 50.55a and GDC 1 with respect to assuring that the safety-related structures other than containment are designed, fabricated, erected, constructed, tested, and inspected to quality standards commensurate with its safety function to be performed by meeting the guidelines of Regulatory Guides and industry standards indicated below.

2. The applicant has met the requirements of GDC 2 by designing the safety-related structures other than containment to withstand the most severe earthquake that has been established for the site with sufficient margin and the combinations of the effects of normal and accident conditions with the effects of environmental loadings such as earthquakes and other natural phenomena.

3. The applicant has met the requirements of GDC 4 by assuring that the design of the safety-related structures are capable of withstanding the dynamic effects associated with missiles, pipe whipping and discharging fluids.

4. The applicant has met the requirements of GDC 5 by demonstrating that structures, systems, and components are not shared between units or that if shared they have demonstrated that sharing will not impare their ability to perform their intended safety function.

5. The applicant has met the requirements of Appendix B because their quality assurance program provides adequate measures for implementing guidelines relating to structural design audits.

   The criteria used in the analysis, design, and construction of all the plant Category I strucutres to account for anticipated loadings and postulated conditions that may be imposed upon each structure during its service lifetime are in conformance with established criteria, codes, standards, and specifications acceptable to the regulatory staff. These include meeting the positions of Regulatory Guides 1.10, 1.15, 1.55, 1.69, 1.91, 1.94, 1.115, 1.142, and 1.143 and industry standards ACI-349 and AISC, "Specifications for the Design, Fabrication, and Erection of Structural Steel for Buildings."

   The use of these criteria as defined by applicable codes, standards, and specifications, the loads and loading combinations; the design and analysis procedures; the structural acceptance criteria; the materials, quality control, and special construction techniques; and the testing and inservice surveillance requirements provide reasonable assurance that, in the event of winds, tornadoes, earthquakes, and various postulated accidents occurring within the structures, the structures will withstand the specified design conditions without impairment of structural integrity or the performance of required safety functions.

## V. IMPLEMENTATION

The following is intended to provide guidance to applicants and licensees regarding the NRC staff's plans for using this SRP section.

Except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein will be used by the staff in its evaluation of conformance with Commission regulations.

Implementation schedules for conformance to parts of the method discussed herein are contained in the referenced regulatory guides.

## VI. REFERENCES


1. ACI 349, "Code Requirements for Nuclear Safety-Related Structures," American Concrete Institute.

2. Regulatory Guide 1.142, "Safety-Related Concrete Structures for Nuclear Power Plants."

3. AISC, "Specification for Design, Fabrication, and Erection of Structural Steel for Buildings," American Institute of Steel Construction.

4. Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants."

5. 10 CFR Part 50, §50.55a, "Codes and Standards."

6. 10 CFR Part 50, Appendix A, General Design Criterion 1, "Quality Standards and Records."

7. 10 CFR Part 50, Appendix A, General Design Criterion 2, "Design Bases for Protection Against Natural Phenomena."

8. 10 CFR Part 50, Appendix A, General Design Criterion 4, "Environmental and Missile Design Bases."

9. 10 CFR Part 50, General Design Criterion 5, Appendix A, "Sharing of Structures, Systems, and Components."

10. 10 CFR Part 50, Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants."

11. Regulatory Guide 1.10, "Mechanical (Caldwell) Splices in Reinforcing Bars of Category I Concrete Structures."

12. Regulatory Guide 1.15, "Testing or Reinforcing Bars for Category I Concrete Structures."

13. Regulatory Guide 1.55, "Concrete Placement in Category I Structures."

14. Regulatory Guide 1.69, "Concrete Radiation Shields for Nuclear Power Plants."

15. Regulatory Guide 1.91, "Evaluations of Explosions Postulated to Occur on Transportation Routes Near Nuclear Power Plants."

16. Regulatory Guide 1.94, "Quality Assurance Requirements for Installation, Inspection, and Testing of Structural Concrete."

17. Regulatory Guide 1.115, "Protection Against Low Trajectory Turbine Missiles."

18. Regulatory Guide 1.143, "Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in LWR Plants."

## APPENDIX A TO SRP SECTION 3.8.4

## INTERIM CRITERIA FOR SAFETY-RELATED MASONRY WALL EVALUATION

The purpose of this appendix is to provide minimum design considerations and criteria for the review of safety-related masonry walls which will meet the design standards specified in subsection II of this SRP section.

1. General Requirements

The materials, testing, analysis, design, construction, and inspection related to the design and construction of safety-related concrete masonry walls should conform to the applicable requirements contained in Uniform Building Code - 1979, unless specified otherwise, by the provisions to this criteria.

The use of other industrial codes, such as ACI-531, ATC-3, or NCMA, is also acceptable. However, when the provisions of these codes are less conservative than the corresponding provisions of these interim criteria, their use should be justified on a case-by-case basis.

In new construction, no unreinforced masonry walls will be permitted. For operating plants, existing unreinforced walls will be evaluated by the provisions of these criteria. Plants applying for operating licenses which have already built unreinforced masonry walls will be evaluated on a case-by-case basis.

2. Loads and Load Combinations

The loads and load combinations shall include consideration of normal loads, severe environmental loads, extreme environmental load, and abnormal loads. Specifically, for operating plants, the load combinations provided in the plant's FSAR shall govern. For operating license applications, the following load combinations shall apply (for definition of load terms, see SRP Section 3.8.4, subsection II.3).

(a) Service Load Conditions

(1) D + L

(2) D + L + E

(3) D + L + W

If thermal stresses due to $T_o$ and $R_o$ are present, they should be included in the above containment, as follows:

(1a) $D + L + T_o + R_o$

(1b) $D + L + T_o + R_o + E$

(1c) $D + L + T_o + R_o + W$

Check load combination for controlling condition for maximum 'L' and for no 'L'.

(b) <u>Extreme Environmental, Abnormal, Abnormal/Severe Environmental, and Abnormal/Extreme Enviromental Conditions</u>

(4) $D + L + T_o + R_o + E'$

(5) $D + L + T_o + R_o + W_t$

(6) $D + L + T_a + R_a + 1.5\ P_a$

(7) $D + L + T_a + R_a + 1.25\ P_a + 1.0\ (Y_r + Y_j + Y_m) + 1.25\ E$

(8) $D + L + T_a + R_a + 1.0\ P_a + 1.0\ (Y_r + Y_j + Y_m) + 1.0\ E'$

In combinations (6), (7), and (8), the maximum values of $P_a$, $T_a$, $R_a$, $Y_j$, $Y_r$, and $Y_m$, including an appropriate dynamic load factor, should be used unless a time-history analysis is performed to justify otherwise. Combinations (5), (7), and (8) and the corresponding structural acceptance criteria of should be satisfied first without the tornado missile load in (5) and without $Y_r$, $Y_j$, and $Y_m$ in (7) and (8). When considering these loads, local section strength capacities may be exceeded under these concentrated loads, provided there will be no loss of function of any safety-related system.

Both cases of L having its full value or being completely absent should be checked.

3. <u>Allowable Stresses</u>

Allowable stresses provided in ACI-531-79, as supplemented by the following modifications/exceptions, shall apply.

(a) When wind or seismic loads (OBE) are considered in the loading combinations, no increase in the allowable stresses is permitted.

(b) Use of allowable stresses corresponding to special inspection category shall be substantiated by demonstration of compliance with the inspection requirements of the NRC criteria.

(c) When tension perpendicular to bed joints is used in qualifying the unreinforced masonry walls, the allowable value will be justified by test program or other means pertinent to the plant and loading conditions. For reinforced masonry walls, all the tensile stresses will be resisted by reinforcement.

(d) For load conditions which represent extreme environmental, abnormal, abnormal/severe environmental, and abnormal/extreme environmental conditions, the allowable working stress may be multiplied by the factors shown in the following table:

| Type of Stress | Factor |
|---|---|
| Axial or Flexural Compression[1] | 2.5 |
| Bearing | 2.5 |
| Reinforcement stress except shear | 2.0 but not to exceed 0.9 fy |
| Shear reinforcement and/or bolts | 1.5 |
| Masonry tension parallel to bed joint | 1.5 |
| Shear carried by masonry | 1.3 |
| Masonry tension perpendicular to bed joint | |
| for reinforced masonry | 0 |
| for unreinforced masonry[2] | 1.3 |

Notes

(1) When anchor bolts are used, design should prevent facial spalling of masonry unit.

(2) See 3(c).

4. Design and Analysis Considerations

(a) The analysis should follow established principles of engineering mechanics and take into account sound engineering practices.

(b) Assumptions and modeling techniques used shall give proper considerations to boundary conditions, cracking of sections, if any, and the dynamic behavior of masonry walls.

(c) Damping values to be used for dynamic analysis shall be those for reinforced concrete given in Regulatory Guide 1.61.

(d) In general, for operating plants, the seismic analysis and Category I structural requirements of FSAR shall apply. For other plants, corresponding SRP requirements shall apply. The seismic analysis shall account for the variations and uncertainties in mass, materials, and other pertinent parameters used.

(e) The analysis should consider both in-plane and out-of-plane loads.

(f) Interstory drift effects should be considered.

(g) In new construction, no unreinforced masonry wall is permitted; also, all grout in concrete masonry walls shall be compared by vibration.

(h) For masonry shear walls, the minimum reinforcement requirements of ACI-531 shall apply.

(i) Special construction (e.g., multiwythe, composite) or other items not covered by the code shall be reviewed on a case-by-case basis for their acceptance.

(j) Licensees or applicants shall submit QA/QC information, if available, for staff review.

In the event QA/QC information is not available, a field survey and a test program reviewed and approved by the staff shall be implemented to ascertain the conformance of masonry construction to design drawings and specificiations (e.g., rebar and grouting).

(k) For masonry walls requiring protection from spalling and scabbing due to accident pipe reaction ($Y_r$), jet impingement ($Y_j$), and missile impact ($Y_m$), the requirements of SRP Section 3.5.3 shall apply. Any deviation from SRP Section 3.5.3 shall be reviewed and approved on a case-by-case basis.

5. Revision of Criteria

The criteria will be revised, as appropriate, based on:

(a) Design review meetings with the selected licensees and their A/Es.

(b) Experience gained during review.

(c) Additional information developed through testing and researches.

6. References


(a) Uniform Building Code - 1979 Edition.

(b) Building Code Requirements for Concrete Masonry Structures ACI-531-79 and Commentary ACI-531R-79.

(c) Tentative Provisions for the Development of Seismic Regulations for Buildings-Applied Technology Council ATC 3-06.

(d) Specification for the Design and Construction of Load-Bearing Concrete Masonry - NCMA August, 1979.

(e) Trojan Nuclear Plant Concrete Masonry Design Criteria Safety Evaluation Report Supplement - November, 1980.

(f) Regulatory Guide 1.61, "Damping Values for Seismic Design of Nuclear Power Plants."

# APPENDIX B TO SRP SECTION 3.8.4

## STRUCTURAL DESIGN AUDITS

1. Introduction

Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," to 10 CFR Part 50, "Licensing of Production and Utilization Facilities," requires, in part, that the design control measures shall provide for verifying or checking the adequacy of simplified calculational methods, or by the performance of a suitable testing program. This appendix provides requirements and guidelines for implementation of structural design audits.

2. Objectives

The audit is conducted in order that the following objectives are accomplished:

(a) To investigate the manner in which the applicant has implemented the structural design criteria that he committed to use for the facility.

(b) To verify that the key structural design calculations have been conducted in an acceptable way.

(c) To identify and assess the safety significance of these areas where the plant structures were designed and analyzed using methods other than those recommended by the SRP section.

3. Preliminary Arrangements

Arrangements for the audit are to be made by the Licensing Project Manager (LPM). The audit agenda, including specific areas of interest are prepared by the reviewer and forwarded to the applicant at least thirty (30) days prior to the date of the audit. The LPM should notify the appropriate I&E regional office personnel as well as any intervening parties, if applicable, about the forthcoming audit.

4. Conduct of the Audit

(a) An Overview of the Plant Design:

The applicant should present an overview of each of the key structures including a brief description, assumptions, modeling techniques, and technique features of design as well as any deviations from those committed to in the SARs.

(b) Audit of Design Calculations:

The auditing personnel review the design calculations for the structures which have been identified during the review of the applicant's Design Report. Any questions such as those regarding the structural modeling, analysis, proportioning of the members, and computer runs should be discussed among the participants in the audit and resolved. If such a resolution required additional engineering data and further analysis on the part of the applicant, the specific followup action items should be identified and noted in the meeting minutes for subsequent resolution.

5. Exit Meeting

An exit meeting is held at the conclusion of the audit to discuss and summarize the audit findings, generic issues pertaining to the design, specific action items, and the schedules for resolution of the action items.

6. Minutes of the Audit

The LPM is responsible for preparation of the audit minutes.

7. After-Audit Meetings

Review of the applicant's response to the action items may necessitate additional meeting(s) between the staff and the applicant to explain certain parts of the responses.

8. Input to the SER

The audit should be considered as an integral part of the review process. Resolution of the action items, together with appropriate consideration of other safety aspects should constitute the major basis for the staff's preparation of the SER.

# APPENDIX C TO SRP SECTION 3.8.4

## DESIGN REPORT

Category I Structures
Design Report
Table of Contents

______________ Structure

## I. OBJECTIVE

The primary objective of the Design Report is to provide the reviewer with design and construction information more specific than that contained in the SAR, which can assist him to plan and conduct a structural audit. For this review, the information must be in quantitative form representing the scope of the actual design computations and the final design results.

## II. STRUCTURAL DESCRIPTION AND GEOMETRY

1. Structural Geometry and Dimensions
2. Key Structural Elements and Description
3. Floor Layout and Elevations
4. Conditions of Vicinity and Supports
5. Special Structural Features

## III. STRUCTURAL MATERIAL REQUIREMENTS

1. Concrete

   a) Compressive Strength
   b) Modulus of Elasticity
   c) Shear Modulus
   d) Poisson's Ratio

2. Reinforcement

   a) Yield Stress
   b) Tensile Strength
   c) Elongation

3. Structural Steel

   a) Grade
   b) Ultimate Tensile Strength
   c) Yield Stress

4. Prestressing Stage (if appliable)

   a) Type of the System (manufacturer)
   b) Description of Tendons
   c) Description of Surcharge

d) Tendons and Sheeting Layout
e) Dome Prestressing

5. Foundation Media

a) General Description
b) Unit Weight
c) Shear Modulus
d) Angle of Internal Friction
e) Cohesion
f) Bearing Capacity

6. Special Considerations

IV. <u>STRUCTURAL LOADS</u>

1. Live and Dead Load Floor Plans

2. Determination of Transient and Dynamic Loads

3. Manufacturer's Date of Equipment Loads

4. Environmental Loads

5. Torsional Effects

V. <u>STRUCTURAL ANALYSIS AND DESIGN</u>

1. Design Computations of Critical Elements

2. Stability Calculations

3. Engineering Drawings Including Details of Connections and Joints

4. Discussion of Unique Features and Problem Resolution

VI. <u>SUMMARY OF RESULTS</u>

1. The Required Sections

2. The Provided Sections

3. Breakdown of Individual Load Contributions

4. Tabulation of Capacities of the Section Versus Capacities Required for Different Failure Modes (Bending, Shear, Axial Load)

5. Margins of Safety Provided

VII. <u>CONCLUSIONS</u>

## APPENDIX D TO SRP SECTION 3.8.4

## TECHNICAL POSITION ON SPENT FUEL POOL RACKS

### Introduction

The purpose of this appendix is to provide minimum requirements and criteria for review of spent fuel pool racks and the associated structures which would meet the design standards specified in subsection II of this SRP section.

(1) Description of the Spent Fuel Pool and Racks

Descriptive information including plants and sections showing the spent fuel pool in relation to other plant structures shall be provided in order to define the primary structural aspects and elements relied upon to perform the safety-related functions of the pool, the spent pool liner fuel, and the racks. The main safety function of the spent fuel pool, including the liner, and the racks is to maintain the spent fuel assemblies in a safe configuration through all environmental and abnormal loadings such as earthquake, and impact due to spent fuel cask drop, drop of a spent fuel assembly, or drop of any other heavy object during routine spent fuel handling.

The major structural elements reviewed and the extent of the descriptive information required are indicated below.

(a) Support of the Spent Fuel Racks: The general arrangements and principal features of the horizontal and the vertical supports to the spent fuel racks should be provided indicating the methods of transferring the loads on the racks to the fuel pool wall and the foundation slab. All gaps (clearance or expansion allowance) and sliding contacts should be indicated. The extent of interfacing between the new rack system and the old fuel pool walls and base slab should be discussed, i.e., interface loads, response spectra, etc.

If connections of the racks are made to the base and to the side walls of the pool such that the pool liner may be perforated, the provisions for avoiding leakage of radioactive water of the pool should be indicated.

(b) Fuel Handling: Postulation of a drop accident, and quantification of the drop parameters are reviewed by the Accident Evaluation Branch (AEB); Structural Engineering Branch accepts the findings of the AEB review for the purpose of review of the integrity of the racks and the fuel pool including the fuel pool lines due to a postulated fuel handling accident. Sketches and sufficient details of the fuel handling system should be provided to facilitate this review.

(2) Applicable Codes, Standards, and Specifications

Construction materials should conform to Section III, Subsection NF of Ref. 3.1. All materials should be selected to be compatible with the fuel pool environment to minimize corrosion and galvanic effects.

Design, fabrication, and installation of spent fuel racks of stainless steel material may be performed based upon Subsection NF requirements of Ref. 3.1 for Class 3 component supports.

(3) Seismic and Impact Loads

For plants where dynamic input data such as floor responses spectra or ground response spectra are not available, necessary dynamic analyses may be performed using the criteria described in SRP Section 3.7. The ground response spectra and damping values should correspond to Regulatory Guides 1.60 and 1.61, respectively. For plants where dynamic data are available, e.g., ground response spectra for a fuel pool supported by the ground, floor response spectra for fuel pools supported on soil where soil-structure interaction was considered in the pool design or a floor response spectra for a fuel pool supported by the reactor building, the design and analysis of the new rack system may be performed by using either the existing input parameters including the old damping values or new parameters in accordance with Regulatory Guides 1.60 and 1.61. The use of existing input with new damping values in Regulatory Guide 1.61 is not acceptable.

Seismic excitation along three orthogonal directions should be imposed simultaneously for the design of the new rack system.

The peak response from each direction should be combined by square root of the sum of the squares in accordance with Regulatory Guide 1.92. If response spectra are available for a vertical and horizontal directions only, the same horizontal response spectra may be applied along the other horizontal direction.

Submergence in water may be taken into account. The effects of submergence are considered on case-by-case basis.

Due to gaps between fuel assemblies and the walls of the guide tubes, additional loads will be generated by the impact of fuel assemblies during a postulated seismic excitation. Additional loads due to this impact effect may be determined by estimating the kinetic energy of the fuel assembly. The maximum velocity of the fuel assembly may be estimated to be the spectral velocity associated with the natural frequency of the submerged fuel assembly. Loads thus generated should be considered for local as well as overall effects on the walls of the rack and the supporting framework. It should be demonstrated that the consequent loads on the fuel assembly do not lead to a damage of the fuel.

Loads generated from other postulated impact events may be acceptable, if the following parameters are described: the total mass of the impacting missile, the maximum velocity at the time of impact, and the ductility ratio of the target material utilized to absorb the kinetic energy.

(4) Loads and Load Combinations:

Any change in the temperature distribution due to the proposed modification should be identified. Information pertaining to the applicable design loads and various combinations thereof should be provided indicating the thermal load due to the effect of the maximum temperature distribution through the pool walls and base slab. Temperature gradient across the rack structure due to differential heating effect between a full and an empty cell should be indicated and incorporated in the design of the rack structure. Maximum uplift forces available from the crane should be indicated including the consideration of these forces in the design of the racks and the analysis of the existing pool floor, if applicable.

The fuel pool racks, the fuel pool structure including the pool slab and fuel pool liner, should be evaluated for accident load combinations which include the impact of the spent fuel cask, the heaviest postulated load drop, and/or accidental drop of fuel assembly from maximim height.

The acceptable limits (strain or stress limits) in this case will be reviewed on a case-by-case basis but in general the applicant is required to demonstrate that the functional capability and/or the structural integrity of each component is maintained.

The specific loads and load combinations are acceptable if they are in conformity with the applicable portions of SRP Section 3.8.4, subsection II.3, and Table 1.

(5) Design and Analysis Procedures

Details of the mathematical model including a description of how the important parameters are obtained should be provided including the following: The methods used to incorporate any gaps between the support systems and gaps between the fuel bundles and the guide tubes; the methods used to lump the masses of the fuel bundles and the guide tubes; the methods used to account for the effect of sloshing water on the pool walls; and, the effect of submergence on the mass, the mass distribution and the effective damping of the fuel bundle and the fuel racks.

The design and analysis procedures in accordance with SRP Section 3.8.4, subsection II.4 are acceptable. The effect on gaps, sloshing water, and increase of effective mass and damping due to submergence in water should be quantified.

When pool walls are utilized to provide lateral restraint at higher elevations, a determination of the flexibility of the pool walls and the capability of the walls to sustain such loads should be provided. If the pool walls are flexible (having a fundamental frequency less than 33 Hertz), the floor response spectra corresponding to the lateral restraint point at the higher elevation are likely to be greater than those at the base of the pool. In such a case using the response spectrum approach, two separate analyses should be performed as indicated below:

(a) A spectrum analysis of the rack system using response spectra corresponding to the highest support elevation provided that there is not significant peak frequency shift between the response spectra at the lower and higher elevations; and

(b) A static analysis of the rack system by subjecting it to the maximum relative support displacement.

The resulting stresses from the two analyses above should be combined by the absolute sum method.

In order to determine the flexibility of the pool wall it is acceptable for the applicant to use equivalent mass and stiffness properties obtained from calculations similar to those described in Ref. 4.1. Should the fundamental frequency of the pool wall model be higher than or equal to 33 Hertz, it may be assumed that the response of the pool wall and the corresponding lateral support to the new rack system are identical to those of the base slab, for which appropriate floor response spectra or ground response spectra may already exist.

(6) Structural Acceptance Criteria

The structural acceptance criteria are those given in the Table 1. When buckling loads are considered in the design, the structural acceptance criteria shall be limited by the requirements of Appendix XVII to Reference 3.1.

For impact loading, the ductility ratios utilized to absorb kinetic energy in the tensile, flexural, compressive, and shearing modes should be quantified. When considering the effects of seismic loads, factors of safety against gross sliding and overturning of racks and rack modulus under all probable service conditions shall be in accordance with SRP Section 3.8.5, subsection II.5. This position on factors of safety against sliding and tilting need not be met provided any one of the following conditions is met:

(a) it can be shown by detailed nonlinear dynamic analyses that the amplitudes of sliding motion are minimal, and impact between adjacent rack modules or between a rack module and the pool walls is prevented provided that the factors of safety against tilting are within the values permitted by SRP Section 3.8.5, subsection II.5.

(b) it can be shown that any sliding and tilting motion will be contained within suitable geometric constraints such as thermal clearances, and that any impact due to the clearances is incorporated.

The fuel pool structure should be designed for the increased loads due to the new and/or expanded high density racks. The fuel pool liner leak tight integrity should be maintained or the functional capability of the fuel pool should be demonstrated.

(7) Materials, Quality Control, and Special Construction Techniques

The materials, quality control procedures, and any special construction techniques should be described. The sequence of installation of the new fuel racks, and a description of the precautions to be taken to prevent damage to the stored fuel during the construction phase should be provided.

If connections between the rack and the pool liner are made by welding, the welder as well as the welding procedure for the welding assembly shall be qualified in accordance with the applicable code.

TABLE 1

| LOAD COMBINATION | ACCEPTANCE LIMIT |
|---|---|
| $D + L$<br>$D + L + T_o$ | Level A service limits |
| $D + L + T_o + E$<br>$D + L + T_a + E$<br>$D + L + T_o + P_f$ | Level B service limits |
| $D + L + T_a + E'$ | Level D service limits |
| $D + L + F_d$ | The functional capability of the fuel racks should be demonstrated |
| **Limit Analysis:** | |
| $1.7 (D + L)$<br>$1.3 (D + L + T_o)$<br>$1.7 (D + L + E)$<br>$1.3 (D + L + E + T_o)$<br>$1.3 (D + L + E + T_a)$<br>$1.3 (D + L + T_o + P_f)$<br>$1.1 (D + L + T_a + E')$ | XVII 4000 of ASME<br>ASME Code Section III |

Notes:

1. The abbreviations in the table above are those used in subsection II.3.a of this SRP section where each term is defined except for $T_a$ which is defined here as the highest temperature associated with the postulated abnormal design conditions.

2. Deformation limits specified by the Design Specification limits shall be satisfied, and such deformation limits should preclude damage to the fuel assemblies.

3. The provisions of NF 3231.1 of Reference 3.1 shall be amended by the requirements of paragraphs c.2.3 and 4 of Regulatory Guide 1.124 entitled "Design Limits and Load Combinations for Class 1 Linear-Type Component Supports."

4. $F_d$ is the force caused by the accidental drop of the heaviest load from the maximum possible height and $P_f$ is upward force on the racks caused by postulated struck fuel assembly.

## VI. REFERENCES

1. Regulatory Guides

   1.29 - Seismic Design Classification

   1.60 - Design Response Spectra for Seismic Design of Nuclear Power Plants

   1.61 - Damping Values for Seismic Design of Nuclear Power Plants

   1.76 - Design Basis Tornado for Nuclear Power Plants

   1.92 - Combining Modal Responses and Spatial Components in Seismic Response Analysis

   1.124 - Design Limits and Loading Combinations for Class 1 Linear-Type Components Supports

2. Standard Review Plan Section

   3.7 - Seismic Design

   3.8.4 - Other Category I Structures

3. Industry Codes and Standards

   1. American Society of Mechanical Engineers, Boiler and Pressure Vessel Code, Section III, Division 1

   2. American National Standards Institute, N210-76

   3. American Society of Civil Engineers, Suggested Specification for Structures of Aluminum Alloys 6061-T6 and 6067-T6

   4. The Aluminium Association, Specification for Aluminum Structures

4. Other

   1. Briggs, John M., "Introduction to Structural Dyanmics," McGraw-Hill Book Co., New York, 1964.